Ocean Rainfall

WITH

Chart and Tables

BY

W. G. BLACK, F.R.M.S.

1864=1875.

DIAGRAMS—OCEAN RAINFALL.

1. SHIP [redacted] Rainfall.
2. Monthly Rainfall.
3. Curves of Rainfall.
4. Chart of Zones.

W. J. Black F.R.C.S.E.

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Read before the Royal Meteorological Society, London, 20th March 1878, with Charts.

THESE remarks on Rainfall at Sea have been deduced from Sets of Observations taken by *Rain Gauges* on board several vessels of the Royal Navy and Mercantile Marine, within the period of about five years, on both long and short voyages in various seas. The results were tabulated into sections, belonging to the *Northern Hemisphere* and to the *Southern Hemisphere*, and both again were divided into columns for each month of the year and summed up into total amounts of Rain, Wet Days, Rate of Rainfall per Wet Day and per Total Days, and also per Degree and per 1000 Nautical Miles.

Diagrams have also been constructed showing the curves of rainfall and wet days for the year, and the rain belts or regions in a chart of the world where rain is more prevalent than in other intervening spaces of latitude. But these are offered for consideration merely as preliminary sketches of what may in future be made out, and are only applicable for a temporary purpose to the present observations.

In the *Northern Hemisphere* the total rainfall came to 94·16 inches, total wet days to 169, total dry days to 501. Rates per wet day of rainfall, ·566 inch. Total wet and dry days, 670. Rate per total days, ·141 inch. Rate per annum, 51·29 inches. Wet days per annum, 92; including observations at Foochow.

In the *Southern Hemisphere* the total rainfall came to 94·70 inches, the total wet days to 253, and the total dry days to 918. Rate per wet day of rainfall, ·330 inch. The total wet and dry days were 1171, and the rate per total days of rainfall was ·110 inch. Rate of rain per annum, 29·43 inches. Wet days per annum, 80; including observations at Fiji Islands.

These figures show that there was *heavier rainfall* in the Northern Hemisphere than in the Southern Hemisphere, but fewer days on which it fell; that the *rate* per wet day is greater also in the Northern Hemisphere than in the Southern Hemisphere, as is also the rate per annum; and that there were more wet days in the Southern Hemisphere than in the Northern Hemisphere at sea, showing the greater preponderance of drizzly weather in the Southern Hemisphere, and the absence of the equatorial rain belt.

The month of *September* (North Autumn) had the heaviest rainfall (26·05 inches) and the greatest number of wet days (33), in the Northern Hemisphere.

The month of *April* (South Autumn) had the least rainfall (17·68 inches), and the month of August (South Winter) 35 inches, the most wet days in the Southern Hemisphere.

The *least amount* of rainfall in the *Northern* Hemisphere occurred in March, ·68 inch (North Spring), and the least number of wet days, 5, in March, also. The least amount of rain in the *Southern* Hemisphere was ·40 inch in October (South Spring), with only 1 wet day in October, also.

The *Spring* may therefore be assumed to be the period of the minimum of rainfall at sea, and the *Autumn* that of its greatest prevalence, in either Hemisphere at different seasons, but at simultaneous periods of the whole year.

The *chart of the curves* for the varying quantities of rainfall, wet days, and rates per diem showed that there was a greater convergence of the lines to minimum degrees for the four months — November, December, January, and February; but that in March they began to diverge remarkably and to undergo maximum oscillations up and down till October, when they again subsided to an equilibrium of parallelism.

The *rates of rainfall* seemed to vary according to the greater or lesser quantity of rain falling; and in the Northern Hemisphere was of least rate, ·136 inch, in March (North Spring), and highest in September, ·789 inch (North Autumn). In the Southern Hemisphere the rate was least in July, ·167 inch (South Winter), and highest, ·370 inch, in April (South Autumn).

The *curves of wet days* seemed to oscillate even more than the curves of rainfall, and to vary in inverse proportion in either Hemisphere, so that when there were fewer wet days in the Northern Hemisphere, there were more in the Southern Hemisphere; and, on the other hand, when there were more wet days in any season in the Northern Hemisphere, there were fewer in the Southern Hemisphere at the corresponding period of the year.

In reference to *latitudes*, the heaviest rainfall was found in the first 7° north of the equator, the demarcation being well defined north and south of this belt—the amounts being 41·72 inches of rain, 65 wet days, and ·642 inch of rate per wet day, and 6·00 inches per degree of latitude, and this may be called the equatorial rain belt.

The *next belts* or regions of prevalence fell between 12°–18° north, and the amounts were 18·38 inches of rain, 22 wet days, and ·83 inch of rate, and 2·62 inches per degree of latitude; and in the Southern Hemisphere the belt lay between 13°–20° south latitude, and the amounts were 23·94 inches of rain, 44 wet days and ·540 inch of rate, and 2·99 inches per degree of latitude, and these may be called the north and south tropical rain belts. These rains seemed chiefly to be dependent on the greater prevalence of *storms*, squalls, and cyclones in these regions in both Hemispheres; while the former were of the more special *tropical* nature, connected with condensation of the super-saturation of the air with vapour.

An increase, again, of rain took place in the regions of the Northern *counter trades* or brave west winds, but with more drizzly or continuous

damp weather, the figures being for the Northern Hemisphere from 40°–51° north latitude, 16·55 inches of rain, 37 wet days and ·45 inch of rate, and 1·38 inches per degree; and for the corresponding region in the Southern Hemisphere from 40°–48° south latitude, 6·81 inches of rain, 33 wet days, ·21 inch of rate, and ·75 inch per degree; but this belt is not so satisfactorily defined as the one in the Northern Hemisphere, and these may be called the north and south temperate rain belts.

It may further be assumed that there might exist between each of these five rainy regions corresponding four drier regions of less prevalence of rain, placed over the same oceans and seas, one situated between each rain belt from 40° north latitude to 40° south latitude.

1. A *north temperate* dry belt would lie between 40° and 18° north latitude, with rainfall of 7·63 inches, wet days 26, rate per diem ·29 inch, rate per degree ·36 inch.

2. A *north tropical* dry region, between 12° and 7° north latitude, with rainfall of 6·86 inches, wet days 12, rate per diem ·57 inch, rate per degree 1·71 inches.

3. A *south tropical* dry belt, between equator and 13° south latitude, with rainfall of 18·70 inches, wet days 47, rate per diem ·41 inch, rate per degree 1·55 inches.

4. A *south temperate* dry region, lying between 20°–40° south latitude, with rainfall of 16·97 inches, wet days 59, rate per diem ·28 inch, and rate per degree ·84 inch. This belt, however, is not so satisfactorily defined as the corresponding one in the Northern Hemisphere, but is announced as a probability.

The *belts of rainfall* need not be assumed to be stationary all the year round, but to be moved towards the equator with the course of the sun on the ecliptic line, and that the present limitation assigned to them in latitude should only be considered as approximate means for a year.

In speculating for an *explanation* of the rain falling more in these belts than in the intervening latitudes, one may venture to state that part of the ascending vapours in the *equatorial* calm belt become condensed in the cooler and rarer upper strata of the atmosphere, above certain heights, and descend then again as rain.

The north and south *tropical* rain belts seem to be chiefly due to rains attending *cyclones*, squalls, and storms, which produce disturbances in the capacity of the air on these occasions, to retain its normal amount of vapour, and so the surplus is condensed and precipitated.

The north and south *temperate* rains beyond 40° latitude are accepted as the remains of the vapours carried on by the *counter trades* from the equatorial calm belt, which are deposited on arriving on the cooler surface of the sea, after their descent at the crossing of the winds in the calms of Cancer and Capricorn.

There seemed some likelihood of assuming that there might be a reciprocal or *vicarious* action between the weather forces in the Northern and Southern Hemispheres, which would cause wet weather to prevail

only alternately in each, so that it might be guessed that when it was wet weather in Britain, there would be dry weather or droughts in Australia or South Africa, and *vice versa*. It further appeared that there was much less rain shown to fall in the *open sea*, even in the tropics, than had been stated by former geographers, as Petermann; as the mean amount for all the voyages in both Hemispheres only reached 40·66 inches per annum. The rainfall was also evidently increased in the gauges when the ships were in harbour, cruising round coast or islands, as seen by the amounts, 10·78 inches for 32 days at anchor at Foochow on the river Min in China, and 27·642 inches for 134 days at anchor among the Fiji Isles.

The total *number of days* occupied by the period of the observations was 1841—225 = both at sea and at anchor, and of these 422 were wet days and 1419 were dry days (taking up a period of 5 years, 17 days, however, including staying at Ports where no observations were taken, which amounted to 166 days altogether), of this total 670 days belonged to the *Northern Hemisphere*, with 169 wet days and 501 dry days; and 1171 belonged to the *Southern Hemisphere*, with 253 wet days and 918 dry days.

The total *amount of rain* for the period of five years came to 188·86 inches for both voyages and anchorages, which would give a rate of 40·36 inches per annum, somewhat about double the annual amount of rain for London, 21·15 inches.

The total number of *days* included in the voyages actually in the *open sea* was 1392, with 345 wet days and 144·773 inches of rainfall, which gives a rate of ·419 inch per wet day, and 37·93 inches per annum; and 1047 dry days, which will give 274 dry and 91 wet days per annum, somewhere about half the usual rate of wet days for London.

The number of *nautical miles* traversed amounted to 105,442, which would give 119 miles per day as the rate of sailing, or about 5 miles per hour; and a rate of rainfall of ·017 inch per hour, and ·235 inch per 60 nautical miles sailed. Of the total miles, 80·087 belonged to the *Northern Hemisphere*, and 85·561 to the *Southern Hemisphere*; and the rate of rainfall per 100 miles in the Northern Hemisphere came to ·114 inch, and in the Southern Hemisphere to ·077 inch.

Further, on estimating the amounts of rain by degrees of latitude, it was found that the rate for the 51° north latitude was 1·787 inches, and that for the 48° south latitude was 1·381 inches, and the total rate for the whole 99° north and south latitudes was 1·570 inches per degree.

When there is a *rain gauge* placed on each side of the ship instead of on deck, in its axis, it is observed that the *lee* one generally gathers more rain than the weather one, and this happens even in steamers where no sails are used, so that the peculiarity *may not* be attributed to the action of the *sails* alone.

The cause more probably is due to the action of the *wind* on the weather side of the ship rising up from the sea level underneath the weather

gauge and driving the rain across the deck, and then down again on the lee side of the ship past the lee gauge to the water level. This was observed during the voyages of *H.M.S. Pearl* and the following *instances* may be quoted:—3rd September 1873, South Indian Ocean—Starboard gauge, ·22 inch of rain, lee side, wind N., N.E., to N.; port gauge, ·13 inch of rain, weather side; course east. 16th September 1873, Australia—Wind N.W. to W., starboard gauge, ·12 inch of rain, weather side; port gauge, ·20 inch of rain, lee side; course south. 17th September 1873—Wind N.W. to S.W.; course east; both gauges, ·18 inch of rain; wind aft. When the ship was lying *at anchor* in the roadstead of Levuka, and swung from the winds, there were little differences, only between the observations of either gauge during rainy weather with winds, which became still less when rains fell during calms.

The five *belts of rain* regions, equatorial, north and south tropical, and north and south temperate, it may be remarked, only as yet would apply in a general way to the Atlantic, Indian, Chinese, and Australian waters, as they have not yet been localised in each sea, from sparsity of observations. Sufficient observations have not either been obtained for the use of the Pacific Ocean, so that no belts have been drafted out on it in the charts. These results of the rainfall at sea, tend to support the views of *Captain Maury* as to the transference of the winds and vapours from one Hemisphere to another by a crossing at the equator, inasmuch as it is seen that the greater rainfall of the Northern Hemisphere might be supplied from the greater extent of ocean surface in the Southern Hemisphere, and the less rainfall of the Southern Hemisphere may be due to the greater extent of land in the Northern Hemisphere with a smaller water exposure.

It may be remarked how very *little rain* falls in the *temperate* latitudes at sea on the further side of 40° in either Hemisphere, called the region of the brave west winds or roaring forties.

Some months in these regions in the diagrams appear *void of collected* rain, as March, April, and November in the Northern Hemisphere, and as the April, November, and December in the Southern Hemisphere; but this statement may be modified by future observations.

It need not be inferred that the weather was dry or fine in these months, but that some of it was *drizzly or misty* with rainfall insufficient to be registered by the instruments on board the ships.

The stormy periods off *Capes Agulhas and Horn* in the three southern winter months of June, July, and August in the temperate regions of the Southern Hemisphere have but small amounts of rain to show for these perturbations of the weather, being only 1·57 inches, 1·22 inches, and 3·71 inches each respectively, with total of 6·50 inches of rain.

In the four stormy winter months of November, December, January, and February, off the *British and Irish coasts*, in the temperate regions, there is also a noteworthy deficiency of rain exhibited by the amounts of 0·0 inches, ·65 inch, ·59 inch, ·25 inch, respectively, and only 1·49 inches for the four months in the Northern Hemisphere further illustrate the statement.

The four *rainy months* of April, May, August, and September, in the *tropical regions* of the Southern Hemisphere appear to be coincident with the four *showery months* of April, May, July, and September in the Northern Hemisphere, as shown by the amounts of 7·59 inches, 9·48 inches, 11·83 inches, 23·01 inches respectively in the Northern Hemisphere, and by 15·36 inches, 12·90 inches, 5·49 inches, and 5·91 inches in the Southern Hemisphere, the total amounts being 51·91 inches for the Northern Hemisphere, and 39·66 inches for the Southern Hemisphere.

The three *wet months* in the temperate regions at sea in the Northern Hemisphere are June, August, and October, with the amounts of 3·96 inches, 4·84 inches, and 3·62 inches of rain, and total of 12·42 inches.

The three *wet months* in the temperate regions at sea in the Southern Hemisphere are February, June, and August, with amounts of 2·69 inches, 1·57 inches, and 3·71 inches of rain respectively, and total of 7·97 inches.

The *driest month* at sea in both Hemispheres seems from these returns to be *December*, with a total of only 2·14 inches of rain and 7 wet days; and this corresponds with a winter in the Northern Hemisphere and a summer in the Southern Hemisphere.

The solstice, therefore, at this period of the year would appear to be attended generally with dry weather over all the seas, in this notice, both North and South of the equator; but the June or North Summer solstice again will appear to be, on the contrary, a showery one, as shown by a total of 13·93 inches of rain and 32 wet days.

On looking at the *chart of the world* with the five rain belts drafted in their assumed latitudes, it will be seen that in the North Atlantic Ocean the north *temperate rain belt* impinges on the coasts of Britain, France, and Spain, Newfoundland and Nova Scotia; that the Cape Verd and Windward Islands lie in the north *tropical rain belt;* and that the *equatorial* belt stretches between Guiana, on the west side, to Liberia and Guinea, on the east. In the *South Atlantic* Ocean, St Helena is included in the south *tropical rain belt* stretching between Brazil and Benguela; while the south *temperate* belt, starting from Patagonia, envelopes Gough Island and others to the eastward. In the *Indian Ocean* we may notice the north *tropical* rain belt stretching between Arabia and Bombay on one side of India, and between the coasts of the Circars and Pegu on the other side, and the *equatorial* belt including the Maldive Islands and parts of Ceylon and Sumatra.

The south *tropical belt* here is assumed to envelope the Mauritius Islands, and to lie between Madagascar and North-west Australia; and the south *temperate* belt goes from the Cape to Tasmania, covering the Crojets and Kerguelen Islands. In the *Chinese and Australian Seas* we suppose the north tropical rain belt to pass over the Philippine Islands, the equatorial belt to stretch east from Singapore over Borneo and Gilolo, the south tropical belt to start from North Queensland to the Fiji Islands, and, lastly, the south temperate rain belt to pass over Tasmania and New Zealand and give them their moist climates as in Great Britain. It may next be inferred that there should be *four dry belts* to correspond

with the five wet belts, placed over the same oceans and seas, one situated between each rain belt from 40° north latitude to 40° south latitude.

1. The north *temperate dry* belt, lying between 40° and 18° north latitude, in which will lie the Azores Islands, the Canaries and Bermuda, the coasts of Carolina, Spain, and Morocco, the Mediterranean, Red Sea, Bays of Arabia and Bengal, and the Chinese coasts and Formosa Island.

2. The north *tropical dry* zone, between 12° and 7° north latitude will be seen investing Sierra Leone, the Orinoco and Laccadive Islands, Cannanore and Pondicherry in India, Nicobar Islands and Tenasserim, Saigon in China, and Palawan and Caroline Islands in the Pacific Ocean.

3. In the south *tropical dry belt*, between the equator and 13° south latitude, may be placed Pernambuco and Fernando Island, Ascension Island and Angola in the Atlantic, Zanzibar, Seychelles Islands, and Java in the Indian Ocean, and New Guinea and Solomon Islands in the Pacific Ocean.

4. In the south *temperate dry* zone, between 20°–40° south latitude, may be seen the River Plate, Tristan d'Acunha, the Cape, the coasts of West, South, and East Australia, and the north part of New Zealand with Auckland; but this and its allied wet zone are not so satisfactorily defined as the corresponding ones in the Northern Hemisphere.

Some remarks are required respecting the rainfall observed at the Fiji Islands by *H.M.S. Pearl*, which is recorded separately on the summary, as there were no data available to fix the positions accurately, and some were obviously taken under anchorage.

The *heaviest rainfall* of the seven months, of October, November, December, January, February, March, and April, occurred in February, 12·05 inches, and the *least* in March, 2·12 inches; and the greatest number of *wet days* were in January, 17, and the least in April, 6; and the heaviest rate of rainfall was in February, ·753 inch, and the lowest *rate* in March, ·212 inch.

These results are supposed to be coincident with the presence of the *south tropical* rain belt and its retreat towards the equator; and after the summer solstice in the Southern Hemisphere is passed and the summer rains have ceased, the south *temperate dry belt* advances from the south tropic line, northwards. There are also a separate set of observations for the harbour of Foochow, which is situated on the Min river, at the south-east coast of China, off the coast. They were taken during the *summer months* of May and June, when the south-west monsoon prevails, and brings a good deal of vapour from the heated China seas to be condensed on the hilly coasts of the Continent. June had a *heavy rainfall* of 7·17 inches, 10 rainy days, and a high rate of ·747 inch per diem, much the same as the maximum at other places on the Northern Hemisphere.

STATEMENT OF VOYAGES OF SHIPS.

1. The *Melbourne* was a sailing ship of 1636 tons burden, having three full-rigged masts, and performed — (1) Voyage from Liverpool to Bombay, via the Cape, from 5th May to 20th September 1868; distance, 15,175 miles; days out, 138; rain collected, 17·33 inches. (2) Voyage from Bombay to Liverpool, from 1st April to 5th September 1869; distance, 14,469 miles; days out, 157; rain collected, 9·00 inches. The position of the rain gauge was not stated in the log books, but it was probably amidships.

2. The *Northfleet* was a sailing ship of three masts, 876 tons burden, commanded by Captain Symington (as was the *Melbourne*), and became historically famous afterwards for its appalling shipwreck, when it was run down at night by the Spanish steamer *Murillo* while at anchor off Dungeness Point, 22nd January 1873. It performed—(1) Voyage from London to Hong Kong, via the Cape, from 15th December 1865 to 8th May 1866; distance, 17,147 nautical miles; days out, 144; rain collected, 27·70 inches. (2) Voyage from Macao to London, via the Cape, from 2nd July to 27th October 1865; distance, 15,270 nautical miles; days out, 118; rain collected, 17·82 inches. (3) Voyage from Gravesend to Sydney, via the Cape, from 17th March to 28th June 1864; distance, 13,862 nautical miles; days out, 100; rain collected, 8·35 inches. (4) Voyage from Sydney to Hong Kong, via Solomon Islands, from 20th September to 10th October 1864; distance, 6206 nautical miles; days out, 57; rain collected, 18·00 inches. (5) Voyage from Hong Kong to Calcutta, via Singapore, from 15th November to 11th December 1865; distance, 2906 nautical miles; days out, 26; rainfall, 3·09 inches. The rain gauge was placed on a standard, 10 feet high, on the front of the poop-deck and in the axis of the ship, and was therefore free from the maximum effects of rolling and lee wind currents, and it was of five-inch diameter and swung on gimbals.

3. The *Hong Kong* was a screw steamer of iron, 1881 tons burden, and schooner-rigged, Captain Symington commanding. She performed—Voyage from Foochow to Gravesend, via the Suez Canal route, from 22nd June to 18th August 1873; days out, 52; nautical miles, 10,273; rainfall, 3·66 inches. The rain gauge was similar to the last ship, one of five inches diameter, but the position is not stated, and the ship has subsequently been wrecked.

4. *H.M.S. Sylvia* was a surveying vessel of the Royal Navy of 887 tons burden, barque-rigged, with auxiliary screw, commanded by Capt. B. St John. The voyage was from Plymouth to Hong Kong, via the Suez Canal, from 4th February to 12th May 1874; days out, 98; nautical miles not stated, but estimated at 10,066; rainfall collected, 6·890 inches. The position of the rain gauge is not stated in the log books, but it was one of six inches diameter poised on a pivot, and the records were generally taken the day after the fall of rain; but in the *Northfleet* they seem to have been taken the same day.

5. *R.M.S. Java*, Captain J. A. Martyn—Voyages from Liverpool to New York and back, via Queenstown, from 10th May to 10th October 1873; days out, 126; days of rain, 23; rainfall collected, 12·02 inches; distance, 3016 nautical miles. Nine Voyages recorded will give total distance, 27·144 nautical miles to and fro over the Atlantic. Tonnage, 2697. She was one of the Cunard Line of mail steamers, a large three-masted ship, with screw propeller. The position of the rain gauge is not stated, but it was one of six inches diameter swung on a pivot, and the observations here recorded were taken the day following the rainfall.

6. *H.M.S. Pearl*, Captain Goodenough in command, was a screw corvette of three masts, 1469 tons burden, and is remarkable historically for the fate which befell her commander, who was assassinated by the natives of the Santa Cruz Islands. There were two rain gauges on this ship, stationed, one on the port and the other on the starboard side, so that one was frequently, when at sea, on the lee side and the other on the windward side of the ship. One, of six inches diameter, was poised on a pivot, and the other, of five inches diameter, was hung on gimbals, but both registered like quantities of rain under similar circumstances. When the ship was at anchor they would both swing to the wind in the same line as the ship, and present each their fronts to the prevailing wind, and, therefore, nearly in equally favourable positions to catch the rain driven aft. When, however, there was a wind more or less abeam, the lee rain gauge generally caught more rain than the windward one, sometimes as much as one-quarter or one-third more, so that in estimating the day's rain it will be quite fair to take the mean between the two. This difference is assumed to be due to the wind ascending the sides of the ship from the sea level past the weather gauge, and descending on the lee gauge down the lee side of the ship to the sea level again. The voyages were (1) from England to Fiji Islands, via the Cape and New Zealand, 11th January to 16th November 1873; distance, 13,054 nautical miles; days out, 168; rain, 6·148 inches. Various voyages in the Pacific and Australian Seas, 17th November 1873 to 12th August 1875; days out, 634; rain collected, 46·97 inches; distance, not stated.

Some additional remarks on Ocean Rainfall may further be found in "Symons' Meteorological Magazine" for April 1876, with a register of a rain gauge on *H.M.S. Sylvia* on a voyage from England to China.

"Nature," vol. vii., page 123.—Letter on Ocean Rainfall by Mr Miller.

"Nature," 9th January 1873. — Letter from Mr Symons on Ocean Rainfall and the *Challenger*.

"Nature," 16th January 1873.—Letter from Mr Black on Rain Gauges on board Ships.

"Nature," 27th November 1873.—Letter from Captain Goodenough on Rain Gauges at Sea.

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RAINFALL AT SEA.

SUMMARY—REGIONAL.

1864-1875.

			Rain Inches	Rainy Days	Rate p. Diem.	Rate p. Deg.	Total Days	Dry Days	Rate per Ann.	Latitude.
Total General			198·93	444	·692		1464	1098	44·74	
Total North Hemisphere			104·23	184	0·56	2·04	751	567	54·09	
Foochoo Harbour			10·88	13	0·83	—	33	20	120·34	26° N.
Total N. Regions			93·35	171	0·54	1·83	718	547	47·45	
Regions.	Atlantic. Indian. Pacific East.	Temperate	16·56	40	0·45	1·38	216	176	27·96	40°—51°
			7·80	28	0·29	0·36	174	146	16·19	19°—39°
		Tropical	18·71	25	0·75	2·62	115	90	66·42	12°—18°
			6·54	11	0·57	1·71	64	53	43·84	8°—11°
		Equatorial	43·74	67	0·64	6·00	150	83	106·43	0°— 7°
Regions.	Atlantic. Indian. Pacific East.	Tropical	18·04	41	0·44	1·14	106	65	61·17	0°—12°
			15·18	26	0·54	2·99	185	159	29·98	13°—20°
		Temperate	25·09	83	0·30	1·47	315	232	29·07	21°—39°
			8·26	44	0·19	0·75	139	95	21·66	40°—48°
Totals S. Regions			66·56	194	0·34	1·34	746	551	32·43	
Figi Islands—Harbours			28·14	66	·425	—·	142	76	72·33	16°—19° S.
Total South Hemisphere			94·70	260	0·33	1·97	888	627	35·39	
Total N. and S. Regions			157·48	334	·464	1·59			39·77	

North Lat.

South Lat.

RAINFALL AT SEA.

MONTHLY SUMMARY.—1864-1875.

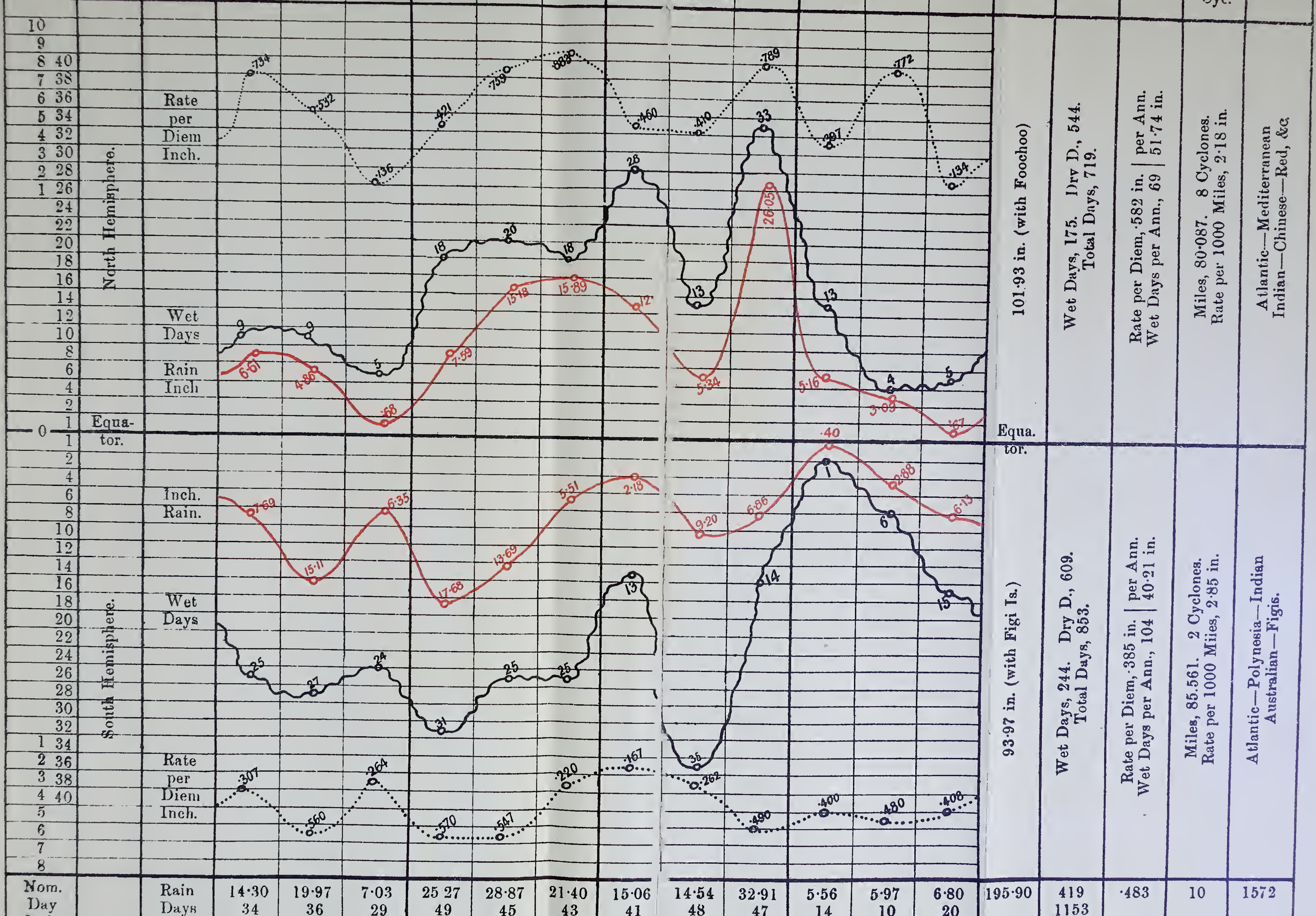
Oceans.	Months.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals.	Total Days Rate.
North Hem.	Rate per Month.	10·78	2·4	·30	3.5	6·9	5·5	3·6	1·1	8·8	3·2	6·2	·8		
Atlantic. Indian, Pacific East.	Foochoo.														
	Rain.					3·31	7·57							10·88	
	Total Days.					5	28							33	
	Wet Days.					2	10							12	
	Rate per W. D.	·734	·582	·136	·421	·659	1·20	·460	·410	·789	·397	·772	·134	·565	·135
	Total Days.	19	56	72	65	66	59	113	76	99	51	15	27	718	
	Wet Days.	10	10	5	19	19	8	29	11	37	13	4	6	171	·210
	Rain Inches.	6·61	4·80	·68	7·59	12·87	8·42	12·88	2·58	28·96	5·16	3·09	·67	93·33	
Equator.															
Atlantic. Indian, Pacific Eastern.	Rain Inches.	1·50	3·06	4·23	15·06	13·69	5·51	2·18	9·91	6·76	·40	2·81	1·47	66·74	
	Wet Days.	8	12	17	26	28	26	14	38	17	2	4	3	195	·261
	Total Days.	16	50	31	91	92	90	102	127	75	38	16	6	746	
	Rate per W. D.	·187	·278	·302	·614	·547	·220	·167	·262	·490	·400	·480	·735	·364	·092
	Fiji Islands.														
	Rain.	6·187	12·55	2·12	2·325						·40	·07	4·962	28·14	
	Total Days.	31	28	31	13						1	14	25	142	
	Wet Days.	17	17	10	6						1	2	13	66	
South Hem.	Rate per Month.	5·7	5·6	3·2	5·1	4·6	1·6	·70	2·4	2·7	·40	2·9	6·4		
Total.	Rain Inches.	14·30	19·97	7·03	25·27	28·87	21·40	15·06	14·54	32·9	5·56	5·97	6·80	199·09	
Total.	Wet Days.	35	39	32	51	47	44	43	49	54	16	10	22	443	
Total.	Days.	66	134	134	169	163	177	215	203	174	90	45	58	1640	


ROYAL COLLEGE OF SURGEONS OF ENGLAND

Ocean Rainfall—Voyages of Ships—1864-1875.

Ships.	Wet Day. Dry Day.	Miles.	Days Out.	Rain. Inches.	Voyage. From	Voyage. To	Dates. From	Dates. To
Melbourne Sailing, 1636 Tons.	45—93	15,175	138	16·98	Liverpool	Bombay	May 5, 1868	Sep. 20, 1868
	30—127	14,469	157	10·71	Bombay	Liverpool	April 1, 1869	Sep. 5, 1869
North Fleet Sailing, 876 Tons	67—78	17,147	144	27·67	London	Hong Kong	Dec. 15, 1865	May 8, 1866
	36—82	15,270	117	17·73	Macao	London	July 2, 1865	Oct. 27, 1865
	29—74	13,862	103	8·01	Gravesend.	Sydney	Mar. 17, 1864	June 28, 1864
	26—32	6,206	57	18·20	Sydney	Hong Kong	Aug. 20, 1864	Oct. 16, 1864
	4—22 5—50	2,906 3,430	26 55	3·09 2·54	Hong Kong Calcutta	Calcutta Hong Kong	Nov. 15, 1865 Jan. 31, 1866	Dec. 11, 1865 Mar. 27, 1866
Hong Kong, S.S. Steam—1881 Tons.	9—42	10,273	52	3·56	Foochou	Gravesend	June 29, 1873	Aug. 18, 1873
Java, R.M. Steam. 2000 Tons.	24—103	27,144	126	12 62	Liverpool New York	New York Liverpool	May 10, 1873	Oct. 10, 1873
H.M.S. Sylvia, Steam. Survey—887 Tons.	19— 80 3—17	10,066 Anchor	98 20	6·75 2·76	Plymouth	Hong Kong Japan	Feb. 4, 1874 Sep. 6, „	May 12, 1874 Sep. 26, „
H.M.S. Pearl, Steam. Survey—1469 Tons.	27—132	13,084 At Sea	158 138	6·638	England Port Nichol	Fiji Is. N. Zeal.	June 11, 1873	Nov. 16, 1873
Various Voyages, Harbour, 282 Days.	106—531	14,890 At Sea	634 346	48·67	Fiji Is. Australia	Australia Fiji Is.	Nov. 17, 1873	Aug. 12, 1875
S.S. Hong Kong, Steam—1881 Tons.	13—15 2— 0	Anchor 522	32 11	10·88 2·17	Foochou India	Harbour At Sea	May 27, 1873 Feb. 16, „	June 28, 1873 Feb. 18, „
Totals.	436/1485	164,848	1943	196·695				

W. G. BLACK, F.R.M.S.


North Hemisphere.
South Hemisphere.
Equator.
Rate per Diem Inch.
Wet Days
Rain Inch
Inch. Rain.
Nom. Day
Rain Days
14·30 34
19·97 36
7·03 29
25·27 49
28·87 45
21·40 43
15·06 41
14·54 48
32·91 47
5·56 14
5·97 10
6·80 20
195·90
419 1153
·483
10
1572
101·93 in. (with Foochoo)
Wet Days, 175. Dry D., 544. Total Days, 719.
Rate per Diem, ·582 in. Wet Days per Ann., 69 | per Ann. 51·74 in.
Miles, 80·087. 8 Cyclones. Rate per 1000 Miles, 2·18 in.
Atlantic—Mediterranean Indian—Chinese—Red, &c.
93·97 in. (with Figi Is.)
Wet Days, 244. Dry D., 609. Total Days, 853.
Rate per Diem, ·385 in. Wet Days per Ann., 104 | per Ann. 40·21 in.
Miles, 85.561. 2 Cyclones. Rate per 1000 Miles, 2·85 in.
Atlantic—Polynesia—Indian Australian—Figis.


NAL COLLEGE OF SURGEONS OF ENGLAND
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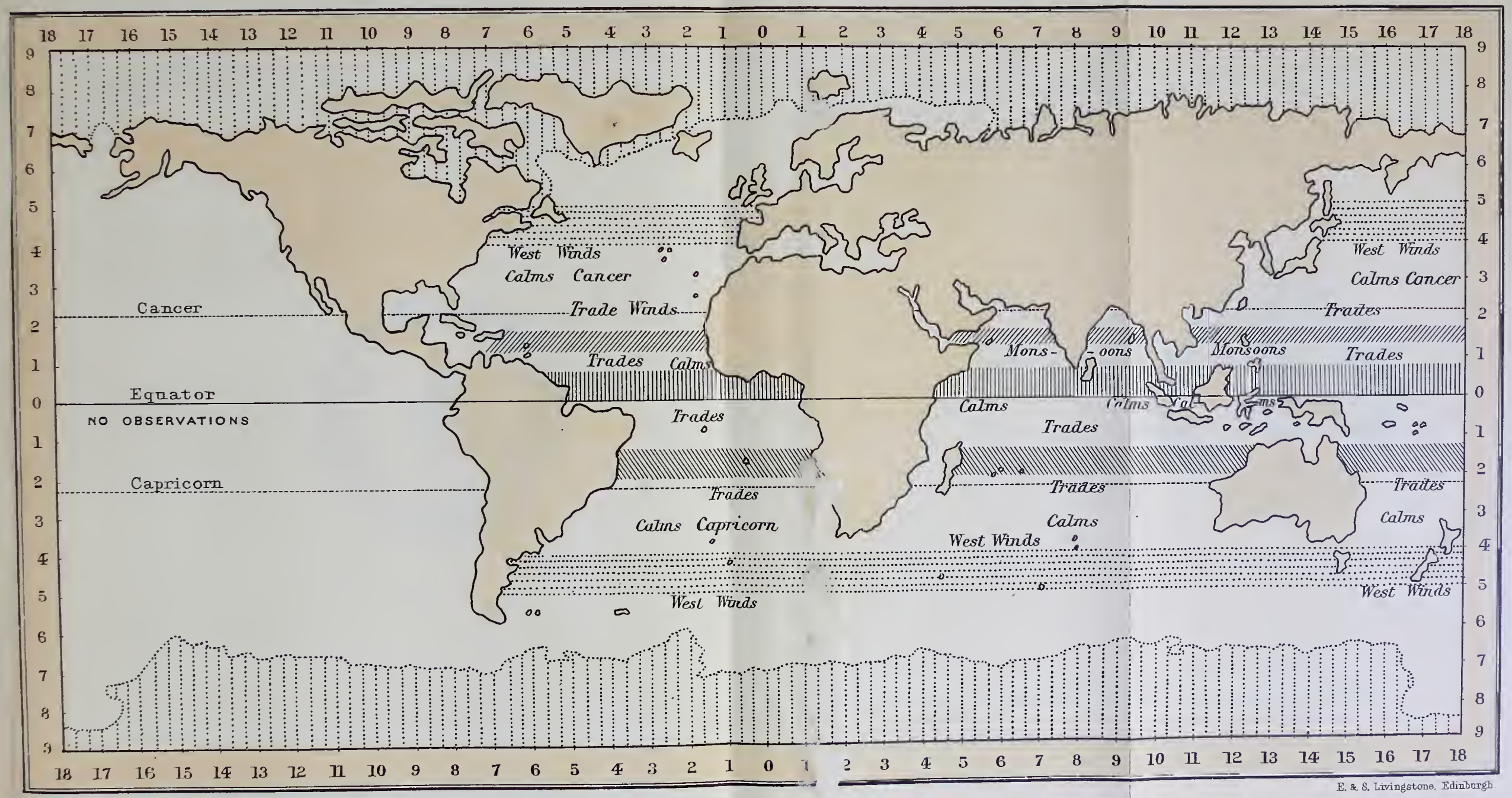
MERCATOR'S CHART OF THE WORLD.

5 ZONES OF OCEAN RAINFALL 1864—75.

1. Equatorial—Between 0°—7° N.L.
2. North Tropical—From 12°—18° N.L.
3. South Tropical—From 13°—20° S.L.
4. North Temperate—From 40°—51° N.L.
5. South Temperate—From 40°—48° S.L.

(Drier Zones intervene between.)



E. & S. Livingstone, Edinburgh

RAINFALL AMOUNTS.

1st Equat. 41·72 in., 65 Wet Days. ·64 in., rate per diem.

4th N. Temp. 16·55 in., 37 Wet Days. ·45 in., rate per diem.


ROYAL COLLEGE OF SURGEONS OF ENGLAND
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